AN1879
Application note

How to use M41ST87 tamper detect and RAM clear

Introduction

The M41ST87 is a supervisory family circuit that provides the industry with the latest in on-chip security solutions. The tamper detection and RAM clear circuit can be used in any system to protect sensitive data from tampering. This chip can be used to secure a wide range of applications from credit card machines and point-of-sale (POS) terminals to electric data meters. The M41ST87 features the ability to detect and timestamp any tampering of the system, and corrupt the device memory when the event occurs. This prevents the intruder from accessing data stored in memory by clearing the device memory and/or external RAM when the tampering event occurs.

Description

How it works

The M41ST87 device provides two independent tamper input pins, $TP1_{IN}$ and $TP2_{IN}$, that can be used to monitor two separate signals. These two tamper input pins can be set to indicate that a tamper event has occurred by either 1) closing a switch (normally open) to ground or V_{OUT} or 2) opening a switch that was previously closed (normally closed) to ground or V_{OUT}. The closing and opening of the switch is configurable using bits that are set in the tamper registers.

The M41ST87 device includes 128 bytes of internal RAM that the user has the option of clearing by setting the TEB and CLR bits in the tamper registers.

Clearing the external memory with the tamper registers

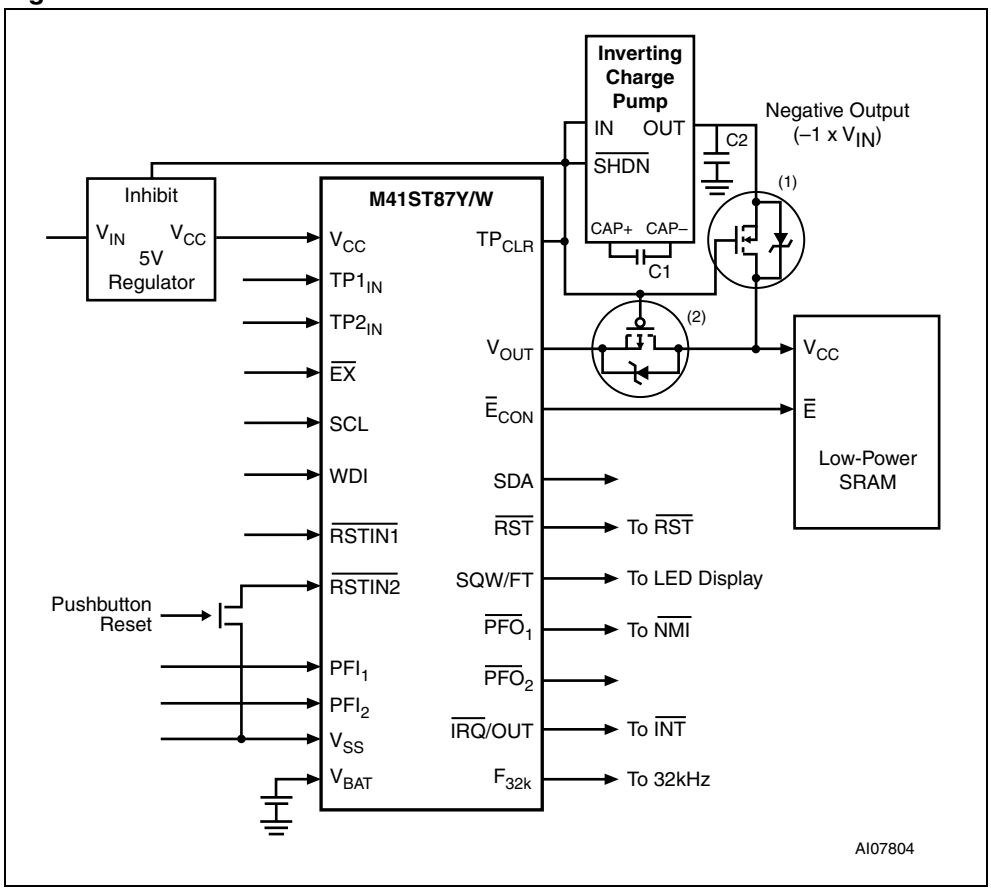
The M41ST87 can also clear the external, battery-backed up SRAM of the device by setting the TEB and CLR_{EXT} bits in the tamper registers. To clear/corrupt the external memory, V_{CC} of the SRAM can be taken to ground. However, certain SRAMs require a significant amount of time for the memory to be corrupted if V_{CC} is simply grounded. To corrupt the memory in a reasonable amount of time, one can take V_{CC} of the SRAM to a negative voltage. By taking V_{CC} to a negative voltage, the input protection diode turns on and goes into conduction mode so that it corrupts the memory.

Clearing the external memory with an external charge pump

An external charge pump device should be used with the M41ST87 to drive V_{CC} of the SRAM to a negative voltage during the tamper condition. *Figure 1 on page 3* shows how to connect this circuit. When using the M41ST87 with the charge pump device, the user must also provide two additional MOSFETs to isolate the V_{OUT} of the M41ST87 from the output (OUT) of the charge pump during normal operation, and from V_{OUT} of the M41ST87 device during the tamper condition. During normal operation the TP_{CLR} signal will be forced low, disabling the charge pump. When disabled, the output of most charge pumps will be forced to Ground. In order to allow proper operation of the SRAM, MOSFET(1) must be “off” to isolate V_{CC} of the SRAM from the charge pump output. At this same time, P-channel MOSFET(2) will be “on” to provide the supply voltage for the SRAM.

During a tamper condition, the TP_{CLR} signal will be forced high, controlling the inhibit pin of the DC regulator. This will put the regulator in standby mode for t_{CLR}. The t_{CLR} is the tamper clear timing where the regulator will be switched off for 1, 4, 8, or 16 seconds, depending on the setting of the CLRPW1 and CLRPW0 bits in the register. The TP_{CLR} signal also enables the charge pump. When the charge pump is enabled, OUT generates a negative voltage on the V_{CC} pin of the SRAM (for a programmable period of time), causing data corruption. The M41ST87 must be isolated from the V_{CC} of the SRAM to avoid data corruption of the M41ST87 due to forward biasing of the parasitic diode of the M41ST87 V_{OUT} output. This is accomplished by using the TP_{CLR} signal to turn the N-channel MOSFET(1) “on,” while turning the P-channel MOSFET(2) “off.”

Figure 1. Circuit connection



1. N-channel MOSFET
2. P-channel MOSFET

RAM clear data

Depending on the process technology used to manufacture the external SRAM, clearing the memory may require varying durations of negative potential on the V_{CC} pin. The M41ST87 device allows the user to program the time needed for their particular application. The control bits CLRPW0 and CLRPW1, located in the day register, determine the duration of the t_{CLR} pulse width during a tamper event (see *Figure 2*). Thus, users can control the voltage and duration of the negative pulse enabling them to configure the circuit for many different LPSRAMs.

At STMicroelectronics, we have evaluated several different SRAMs with different densities and found that we were able to corrupt the memory with certain minimum duration (1 second) negative pulse widths (see *Table 1*).

Figure 2. Tamper output timing

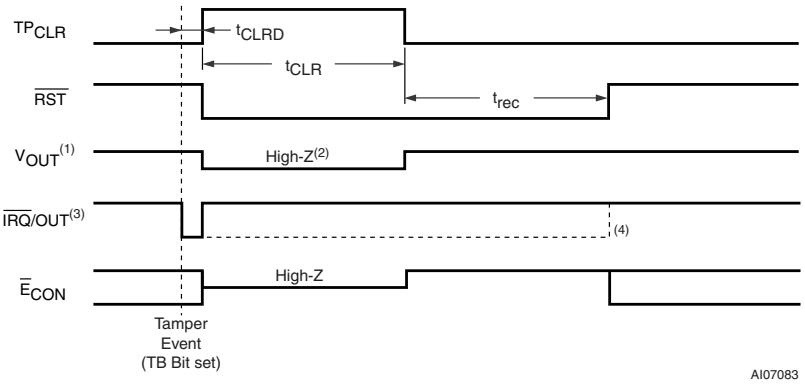


Table 1. RAM clear data with different vendors

	SRAM	Cypress	Hyundai	Hitachi	Cypress	Hyundai	Samsung	ST	Unit
	Density	**1 Mb**	**1 Mb**	**4 Mb**	**4 Mb**	**4 Mb**	**4 Mb**	**4 Mb**	
Before Tamper	V_{BAT}	2.55	2.55	2.55	2.55	2.55	2.55	2.55	V
	V_{OUT}	2.390	2.390	2.426	2.425	2.400	2.423	2.413	V
	I_{IN}	0	0	0	0	0	0	0	µA
	Total I_{BAT}	925.0	582.0	567.0	578.0	752.0	492.0	587.0	nA
During Tamper(1)	I_{SRAM}	–259.2	–267.2	–272.7	–287.7	–275.9	–382.0	–283.2	µA
	V_{IN}	2.042	2.030	2.022	2.000	2.018	2.010	2.010	V
	I_{IN}	316.8	323.0	327.4	339.5	329.8	335.0	336.0	µA
	V_{SRAM}	–0.522	–0.488	–0.465	–0.397	–0.449	–0.425	–0.421	V
	Total I_{BAT}	319.2	325.0	329.6	340.8	331.6	336.5	337.4	µA
	Status	Corrupted							

1. Typically some SRAMs would take > 10 seconds when V_{CC} is taken to V_{SS} at 25°C to corrupt the memory.

Keys:

V_{BAT} = Battery voltage

V_{OUT} = Voltage output

I_{IN} = Current into charge pump before and during tamper condition

Total I_{BAT} = Battery backup current of both the M41ST87 and the SRAM

I_{SRAM} = Current sink into the external SRAM

V_{IN} = Voltage at the charge pump input during tamper condition

V_{SRAM} = Negative voltage produced by the charge pump at SRAM V_{CC} during tamper condition

Tamper timestamp

When the device is tampered with, and regardless of which tamper occurs first, a time stamp freezing the update of the clock registers will occur to let the user know when it was tampered with. The tamper bits (TB1 or TB2 in the flag register) will be set immediately. Therefore, when tampering occurs, the user may elect to first read the time registers to determine exactly when the tamper event occurred, then read the flag register to see which tamper condition was triggered. The clock will update to the current time after resetting the TEB bit in the tamper registers. The appropriate TEB bit must always be reset to '0' in order to read the current time. The tamper detect function operates in V_{CC} as well as in battery backup.

Conclusion

With the increasing frequency of credit card fraud and identity theft, ST is leading the way protecting this sensitive data with its new line of secure RTCs. This sensitive data is stored in internal or external memory of most devices like ATM machines or POS terminals. The M41ST87 solution can provide early detection when these devices have been tampered with and clear the RAM before the intruder can access this data.

Revision history

Table 2. Document revision history

Date	Revision	Changes
04-Feb-2004	1	First edition
12-Apr-2004	2	Reformatted; update vendor SRAM information (*Table 1*)
03-Jun-2004	3	Correct drawing (*Figure 1*)
16-Jan-2009	4	Reformatted document; updated cover page, *Clearing the external memory with an external charge pump*, *Figure 1*, and *RAM clear data*.

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